

The Overall Report On Lactic Acid

There are several reasons why lactic acid is deserving of attention by this Chemurgic Conference. First, lactic acid is produced commercially by the fermentation of the agricultural by-products — starch hydrolyzates, molasses and whey. Second, the industrial production and utilization of lactic acid was originally developed in this country. This industry was well-established in the U.S. before manufacturing was undertaken in foreign countries. Third, this chemurgic industry, although admittedly small in comparison with other larger and better known chemurgic developments, is expected to experience a well-founded growth.



Dr. Woodward

The name, lactic acid, is derived from the fact that it is the primary acid constituent of sour milk. Lactic acid is widely distributed in nature. It is found in the soil, in the blood and muscle tissue of animals and in yeast fermentation. Abnormally high lactic acid values in human blood have been observed in pneumonia, tuberculosis, and heart failure. This acid is also found in sauerkraut, pickles, beer, buttermilk and cheese, silage and corn steep liquor. Known also as alpha-hydroxypropionic acid, it is a member of the class of naturally occurring hydroxy acids which includes citric, tartaric, and malic acid.

The lactic acid industry has developed within the last 70 years and stems from the first plant established in 1881 in Littleton, Mass. by Charles E. Avery.

Lactic acid can be made by the fermentation of several low cost, abundant raw materials including starches, wood, whey, sucrose, invert sugar, molasses and sulfite waste liquor. It can also be prepared by alkaline degradation of hexose sugars or by the high pressure reaction of acetaldehyde and carbon monoxide. Insofar as we are aware, the fermentation of starch hydrolyzates and molasses are the only commercial procedures presently employed.

There are obviously many variables to be considered in the production of lactic acid of different commercial grades. The quantity and nature of the impurities in the final product are dependent upon the purity of essentials in the original mash, the manufacturing process, and the degree of refinement.

Lactic acid is presently marketed in four different grades. These grades in order of increasing order of quality are:

1. Crude, technical or commercial
2. Edible
3. Plastics
4. N.F. (Formerly U.S.P.)

The technical grade is sold in aqueous solution at 22, 44 and 80% concentrations. Relatively impure carbohydrate substrates are employed in its production.

Numerous and varied techniques have been employed to obtain the three refined grades of lactic acid from fermentation liquors. There are two procedures: (1) those employing a distillation step and, (2) procedures in which distillation is avoided.

One of the oldest methods for purifying lactic acid is steam distillation under vacuum. A second method, and one of the most practical developed to date, involves esterification of lactic acid with methanol. The methyl lactate is purified by distillation and the distillate then hydrolyzed with water. Methanol is distilled from the hydrolysis reaction and the residue comprises an aqueous solution of lactic acid.

Examples of purification without distillation follow: The calcium lactate solution produced in fermentation may be clarified by filtration and concentrated to saturation at elevated temperatures. The calcium lactate crystallizes with cooling. The crystals are separated by filtration on centrifugation, then redissolved in water and acidified with sulfuric acid. The calcium sulfate is removed by filtration and the aqueous lactic acid filtrate concentrated.

Another isolation procedure is the liquid-liquid extraction with water-immiscible organic solvents, of which isopropyl ether is an example.

Being one of the most corrosive acids known, lactic acid imposes problems in storage and shipment as well as in production. Iron, steel, copper and its alloys, chrome steel, and monel metal are non-resistant. Inconel, pure nickel, and low iron alloys containing large percentages of nickel and chromium are fairly resistant. Silver and tantalum are most resistant. The commercial grades are sold in oak, cypress, or pitch pine, wooden or paraffin-lined barrels or lined tank cars. Better grades are sold in glass-lined tank cars or carboys.

Utilization of lactic acid can be divided into two categories: food uses and non-food purposes. It is used in animal food and remedies, bakery products, beer, butter, candy, cheese, dried egg whites, flavoring extracts, jelly, liquid pectin, mince meat, olives, pickles, sauerkraut, soft drinks, soap, sherbet and water ice. It has a mildly acid taste, does not mask or overpower other flavors and prevents deterioration in some foods.

Non-food uses include adhesives, cleaning and polishing formulations, insecticides and fungicides, lithographic developers, oil and water well treating, plastics and resins, special inks, tanning and textiles.

Lactic acid derivatives such as sodium, calcium and iron salts and the methyl, ethyl and butyl esters have all found commercial applications.

The lactic acid story to date has been one of gradual but steady development. We anticipate a similar future trend. Present lactic acid sales are reported to be on the increase due to small increases in a variety of applications rather than to any outstanding new developments. These uses have been developed generally by consumers in specialty fields.

However, with new advances in lactic acid technology and the development of new uses for this versatile chemical, domestic consumption could be increased considerably. For example, Needle and Aries, reported recently, "It has been variously stated and estimated that if lactic acid could be obtained for less than 10 cents per pound and preferably at 8 cents per pound on a 100% basis, a potential market of 200 million pounds annually, would be tapped. Arrival at the estimate given can be very readily understood when one notes that the alkyd resin field alone enjoys a volume sale of over 130 million pounds annually and is expected to continue to rise." These technical market specialists considered 8 cents a pound lactic acid and 10 cents a pound methyl lactate a possibility if blackstrap molasses could be obtained for 1 cent a pound.

From a technical standpoint, increased consumption of lactic acid could be implemented by developments along the following two distinct lines:

(1) Improvements in the recovery of lactic acid, as such or a derived product, from fermentation liquors.

(2) The development of new uses for lactic acid through the preparation, characterization, and use evaluation of new lactic acid derivatives. The lactic acid research program at the Eastern Regional Research Laboratory has been based upon these two lines of activity and definite advances have been made in both.